X-ray scattering of atoms and molecules dressed with strong femtosecond laser fields

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The goal of the program is to use the femtosecond x-ray beam line 5.3.1 at the Advanced Light Source to study x-ray absorption and excitation of atoms and molecules modified and evolving in strong, controllable electromagnetic fields.

We measured charge state distribution of K and Ar ions as a function of x-ray energy. The potassium atomic structure is similar to argon atomic closed-shell structure with an additional electron in the 4s state. The measured charge state distribution exhibit markedly different shapes but very close mean values of the charge state. We are currently analyzing the data to unravel the physics played by the extra 4s-electron of potassium in the de-excitation pathway when a K-vacancy is created.

We used a 1 mJ femtosecond laser pulse to remove the 4s-electron of K. We measured the charge state distribution with laser-on and laser-off as the x-ray energy is scanned through the K-edge. The data, taken in an event mode, is currently being analyzed.

Time-of-flight techniques usually use the two-bunch mode that limits the time the experiments can run. We modified our experimental set up and developed a state-of-the-art time-of-flight technique based on a pulsed-extraction and pulsed acceleration to use the multi-bunch mode. This technique allows the extraction of ions created in a single-camshaft pulse of the ALS train of pulses.

The relaxation of a K-hole following x-ray photoionization around the K-edge results in K^{4+} as the most probable charge state. In addition the 1-mJ and 1-kHz femtosecond laser pulses ionize every single K atom in the laser focus. This results in 10^6 to 10^8 K^+ ions being created along for every high charge-state ion (K^{3+} and up) created by the x-rays. A combination of nanosecond-switching high-voltage extraction allowed us to sort with very high efficiency the high charge-state ions from the very large number of K^+. This new set up is uniquely suited to do gas-phase pump-probe experiment.

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